



UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL OCEAN SERVICE  
Hollings Marine Laboratory  
331 Fort Johnson Road  
Charleston, South Carolina 29412

February 20, 2019

Ms. Cindi Punihaole Kennedy, Director  
The Koiiala Center  
Kahalu'u Bay Education Center  
P. O. Box 437462  
Kamuela, Hawai'i Island, Hawai'i 96743

Dear Ms. Punihaole Kennedy:

This letter is in response to your request of January 31, 2019, asking me to provide a hazard assessment for Kahalu'u Bay corals and other marine organisms. At the time of the request, you also provided environmental concentration data for oxybenzone from five sites that had been collected for Kahalu'u Bay on April 14, 2018. The effect concentrations used for the analysis were obtained from the published scientific literature based on a literature review that I performed.

In undertaking this assessment, there were a number of approaches found in the scientific literature and government guidance documents [e.g., references 1-8] to calculate a hazard (or risk) quotient. I used two different approaches to determine the hazard quotient for Kahalu'u Bay, Hawaii Island.

The first approach I used was based on the U.S. Environmental Protection Agency (U.S. EPA) guidance for pesticides and other chemicals [1] which included an effects determination for Endangered and Threatened species [2]. With this method, the measured environmental concentration (MEC) is compared to a toxicity endpoint (e.g.,  $LC_{50}$  that is the concentration of a chemical where 50% of the organisms die or  $EC_{50}$  concentration of the chemical, which results in a 50% adverse effect for a relevant sub-lethal endpoint). For aquatic animals, the lowest  $EC_{50}$  or  $LC_{50}$  measurements are used as the toxicity endpoint. Thus, the **acute risk or hazard quotient, RQ (or HQ) = MEC/most sensitive organism's  $EC_{50}$  or  $LC_{50}$** . This quotient then is compared to U.S. EPA's Level of Concern (LOC) for aquatic animals [1, 2]. The LOC is a policy tool used to interpret the RQ (HQ) and determine potential risk and regulatory action. For aquatic animals the presumption for acute high risk is a RQ of 0.5 (LOC), acute restricted use is a RQ of 0.1 (LOC) and for acute endangered species the RQ is 0.05 (LOC) [1, 2]. These calculations are presented in Table 1. I have used an arbitrary color scheme for easier visualization: **red**  $\geq 0.5$  is high ecological risk; **yellow**  $\geq 0.1 < 0.5$  is moderate risk and potential for restricted use; **green**  $\geq 0.05 < 0.1$  is low risk.

The second approach I used for determining the hazard (or risk) quotient was based on European Union guidance that is internationally accepted, and has been adopted in the development of several ecological risk assessment guidelines [3-7]. With this method, the actual or predicted environmental concentration is compared to an extrapolated or derived Predicted No-Effect Concentration (PNEC) that is divided by an uncertainty (or assessment) factor (UF). Thus, the **HQ = (MEC/PNEC)\*UF**. For this HQ determination,

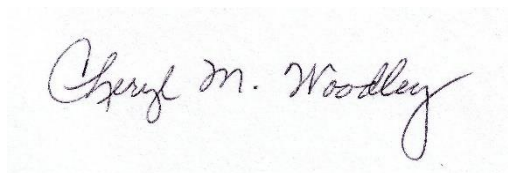


an UF of 1000 was selected for the extrapolation of the EC<sub>50</sub> or LC<sub>50</sub> values to estimate no-effect values (PNEC) [3, 5, 8]. These calculations are presented in Table 2. I have used an arbitrary color scheme for ease of visualization: **red**  $\geq 1$  is high, unacceptable risk; **yellow**  $\geq 0.5 < 1$  is possibility of increased risk; and **green**  $< 0.5$  is low risk.

Hazard Quotients are an initial tier of an ecological risk assessment and meant as a screening tool. The HQ method is not intended to be predictive for the level or magnitude of risk. Based on the guidance by U.S. EPA [1, 2], the most sensitive organism represented in this dataset is *Stylophora pistillata* and specifically the planula exposed to oxybenzone during a 24h exposure involving light (LC<sub>50</sub> = 1.39  $\mu\text{g/L}$ ). Based on these data, Sites HEL1, HEL2, HEL3, and HEL4 exhibited high acute risk; using the EU method of calculating a HQ, all sites indicated high acute risk potential for all organisms examined.

Please let me know if you have any questions or need clarification.

Best Regards,

A handwritten signature in cursive script that reads "Cheryl M. Woodley". The signature is written in dark ink on a light-colored, slightly textured background.

Cheryl M. Woodley, Ph.D.  
Program Manager  
Coral Health & Disease Program.

Attachments:

1. Table 1 Hazard quotient for Kahalu'u Bay, Hawai'i Island, Hawaii using U.S. EPA Approach
2. Table 2 Hazard quotient for Kahalu'u Bay, Hawai'i Island, Hawaii using European Union Approach
3. References

Table 1 Hazard quotient for Kahalu'u Bay, Big Island, Hawaii using US EPA Approach

<b>HQ=MEC/EC<sub>50</sub> (or LC<sub>50</sub>)</b>					HEL 1	HEL 2	HEL 3	HEL 4	HEL 6	Ref.
				Oxybenzone MEC µg/L	440.0	134.0	1721.0	2947.0	5.0	
SPECIES			Toxicity Reference Value µg/L							
<i>Stylophora pistillata</i>	coral cells 4h dark	LC <sub>50</sub>	679.00		0.65	0.20	2.53	4.34	0.01	9
<i>Stylophora pistillata</i>	coral cells 4h light	LC <sub>50</sub>	42.00		10.48	3.19	40.98	70.17	0.12	9
<i>Pocillopora damicornis</i>	coral cells 4h light	LC <sub>50</sub>	8.00		55.00	16.75	215.13	368.38	0.63	9
<i>Acropora cervicornis</i>	coral cells 4h light	LC <sub>50</sub>	9.00		48.89	14.89	191.22	327.44	0.56	9
<i>Orbicella annularis</i>	coral cells 4h light	LC <sub>50</sub>	74.00		5.95	1.81	23.26	39.82	0.07	9
<i>Montastraea cavernosa</i>	coral cells 4h light	LC <sub>50</sub>	52.00		8.46	2.58	33.10	56.67	0.10	9
<i>Porites astreoides</i>	coral cells 4h light	LC <sub>50</sub>	340.00		1.29	0.39	5.06	8.67	0.01	9
<i>Porites divaricata</i>	coral cells 4h light	LC <sub>50</sub>	36.00		12.22	3.72	47.81	81.86	0.14	9
<b>Coral Planula (early life stage)</b>										
<i>Stylophora pistillata</i>	Planula 8h dark	LC <sub>50</sub>	12800.00		0.03	0.01	0.13	0.23	0.00	9
<i>Stylophora pistillata</i>	Planula 8h light	LC <sub>50</sub>	2900.00		0.15	0.05	0.59	1.02	0.00	9
<i>Stylophora pistillata</i>	Planula 24h dark	LC <sub>50</sub>	799.00		0.55	0.17	2.15	3.69	0.01	9

<i>Stylophora pistillata</i>	Planula 24h light	LC <sub>50</sub>	1.39		316.55	96.40	1238.13	2120.14	3.60	9
<i>Stylophora pistillata</i>	Planula deformity 8h dark	EC <sub>50</sub>	737000.00		0.00	0.00	0.00	0.00	0.00	9
<i>Stylophora pistillata</i>	Planula deformity 8h light	EC <sub>50</sub>	133000.00		0.00	0.00	0.01	0.02	0.00	9
<i>Stylophora pistillata</i>	Planula deformity 24h dark	EC <sub>50</sub>	137.00		3.21	0.98	12.56	21.51	0.04	9
<i>Stylophora pistillata</i>	Planula deformity 24h light	EC <sub>50</sub>	49.00		8.98	2.73	35.12	60.14	0.10	9
<b>Invertebrates</b>										
<i>Paracentrotus lividus</i>	sea urchin	EC <sub>50</sub>	3280.00		0.13	0.04	0.52	0.90	0.00	10
<i>Mytilus galloprovincialis</i>	mussels	EC <sub>50</sub>	3472.59		0.13	0.04	0.50	0.85	0.00	10
<i>Siriella armata</i>	mysid, crustacean	EC <sub>50</sub>	710.76		0.62	0.19	2.42	4.15	0.01	10
<i>Daphnia magna</i>	crustacean 24h immobility	EC <sub>50</sub>	2700.00		0.16	0.05	0.64	1.09	0.00	11
<i>Daphnia magna</i>	crustacean 48h immobility	EC <sub>50</sub>	1670.00		0.26	0.08	1.03	1.76	0.00	12
<i>Daphnia magna</i>	crustacean 72h immobility	EC <sub>50</sub>	1600.00		0.28	0.08	1.08	1.84	0.00	11
<i>Daphnia magna</i>	crustacean 24h	LC <sub>50</sub>	7630.00		0.06	0.02	0.23	0.39	0.00	17
<i>Daphnia magna</i>	crustacean 48h	LC <sub>50</sub>	1090.00		0.40	0.12	1.58	2.70	0.00	18
<b>Algae</b>										
<i>Isochrysis galbana</i>	microalgae	EC <sub>50</sub>	13.87		31.72	9.66	124.08	212.47	0.36	10
<i>Desmodesmus subspicatus</i>	Green algae growth	EC <sub>50</sub>	960.00		0.46	0.14	1.79	3.07	0.01	12
<i>Chlamydomonas reinhardtii</i>	green microalgae	EC <sub>50</sub>	1850.00		0.24	0.07	0.93	1.59	0.00	13
<i>Microcystis aeruginosa</i>	cyanobacterium	EC <sub>50</sub>	2460.00		0.18	0.05	0.70	1.20	0.00	13
<i>Skeletonema pseudocostatum</i>	algal diatom growth inhibition	EC <sub>50</sub>	251.00		1.75	0.53	6.86	11.74	0.02	14
<i>Chlorella vulgaris</i>	green microalgae growth inhibition	EC <sub>50</sub>	22400.00		0.02	0.01	0.08	0.13	0.00	15

<i>Chlorella vulgaris</i>	green microalgae growth inhibition 96h	EC <sub>50</sub>	6860.00		0.06	0.02	0.25	0.43	0.00	17
<i>Chlorella vulgaris</i>	green microalgae growth inhibition 96h	EC <sub>50</sub>	2980.00		0.15	0.04	0.58	0.99	0.00	18
<i>Fish</i>										
<i>Brachydanio rerio</i>	96h	LC <sub>50</sub>	14730.00		0.03	0.01	0.12	0.20	0.00	17
<i>Brachydanio rerio</i>	96h	LC <sub>50</sub>	3890.00		0.11	0.03	0.44	0.76	0.00	18

Red - High Risk LOC aquatic animals  $\geq 0.5$

Yellow – Moderate Risk, LOC aquatic animals  $\geq 0.1 < 0.5$

Green – Low Risk, LOC  $\geq 0.05 < 0.1$

White – not significant, below threshold for hazard quotient

Table 2 Hazard Quotient for Kahalu'u Bay, Big Island Hawaii using European Union Approach

					HEL 1	HEL 2	HEL 3	HEL 4	HEL 6	Ref.
HQ=MEC/PNEC*1000				Oxybenzone MEC µg/L	440.0	134.0	1721.0	2947.0	5.0	
SPECIES			Toxicity Reference Value µg/L							
<i>Stylophora pistillata</i>	coral cells 4h dark	LC <sub>50</sub>	679.00		648.0	197.3	2534.6	4340.2	7.4	9
<i>Stylophora pistillata</i>	coral cells 4h light	LC <sub>50</sub>	42.00		10476.2	3190.5	40976.2	70166.7	119.0	9
<i>Pocillopora damicornis</i>	coral cells 4h light	LC <sub>50</sub>	8.00		55000.0	16750.0	215125.0	368375.0	625.0	9
<i>Acropora cervicornis</i>	coral cells 4h light	LC <sub>50</sub>	9.00		48888.9	14888.9	191222.2	327444.4	555.6	9
<i>Orbicella annularis</i>	coral cells 4h light	LC <sub>50</sub>	74.00		5945.9	1810.8	23256.8	39824.3	67.6	9
<i>Montastraea cavernosa</i>	coral cells 4h light	LC <sub>50</sub>	52.00		8461.5	2576.9	33096.2	56673.1	96.2	9
<i>Porites astreoides</i>	coral cells 4h light	LC <sub>50</sub>	340.00		1294.1	394.1	5061.8	8667.6	14.7	9
<i>Porites divaricata</i>	coral cells 4h light	LC <sub>50</sub>	36.00		12222.2	3722.2	47805.6	81861.1	138.9	9
<b>Coral Planula (early life stage)</b>										
<i>Stylophora pistillata</i>	Planula 8h dark	LC <sub>50</sub>	12800.00		34.4	10.5	134.5	230.2	0.4	9
<i>Stylophora pistillata</i>	Planula 8h light	LC <sub>50</sub>	2900.00		151.7	46.2	593.4	1016.2	1.7	9
<i>Stylophora pistillata</i>	Planula 24h dark	LC <sub>50</sub>	799.00		550.7	167.7	2153.9	3688.4	6.3	9
<i>Stylophora pistillata</i>	Planula 24h light	LC <sub>50</sub>	1.39		316546.8	96402.9	1238129.5	2120143.9	3597.1	9

<i>Stylophora pistillata</i>	Planula deformity 8h dark	EC <sub>50</sub>	737000.00		0.6	0.2	2.3	4.0	0.0	9
<i>Stylophora pistillata</i>	Planula deformity 8h light	EC <sub>50</sub>	133000.00		3.3	1.0	12.9	22.2	0.0	9
<i>Stylophora pistillata</i>	Planula deformity 24h dark	EC <sub>50</sub>	137.00		3211.7	978.1	12562.0	21510.9	36.5	9
<i>Stylophora pistillata</i>	Planula deformity 24h light	EC <sub>50</sub>	49.00		8979.6	2734.7	35122.4	60142.9	102.0	9
<b>Invertebrates</b>										
<i>Paracentrotus lividus</i>	sea urchin	EC <sub>50</sub>	3280.00		134.1	40.9	524.7	898.5	1.5	10
<i>Mytilus galloprovincialis</i>	mussels	EC <sub>50</sub>	3472.59		126.7	38.6	495.6	848.6	1.4	10
<i>Siriella armata</i>	mysid, crustacean	EC <sub>50</sub>	710.76		619.1	188.5	2421.4	4146.3	7.0	10
<i>Daphnia magna</i>	crustacean 24h immobility	EC <sub>50</sub>	2700.00		163.0	49.6	637.4	1091.5	1.9	11
<i>Daphnia magna</i>	crustacean 48h immobility	EC <sub>50</sub>	1670.00		263.5	80.2	1030.5	1764.7	3.0	12
<i>Daphnia magna</i>	crustacean 72h immobility	EC <sub>50</sub>	1600.00		275.0	83.8	1075.6	1841.9	3.1	11
<i>Daphnia magna</i>	crustacean 24h	LC <sub>50</sub>	7630.00		57.7	17.6	225.6	386.2	0.7	17
<i>Daphnia magna</i>	crustacean 48h	LC <sub>50</sub>	1090.00		403.7	122.9	1578.9	2703.7	4.6	18
<b>Algae</b>										
<i>Isochrysis galbana</i>	microalgae	EC <sub>50</sub>	13.87		31723.1	9661.1	124080.7	212473.0	360.5	10
<i>Desmodesmus subspicatus</i>	Green algae growth	EC <sub>50</sub>	960.00		458.3	139.6	1792.7	3069.8	5.2	12
<i>Chlamydomonas reinhardtii</i>	green microalgae	EC <sub>50</sub>	1850.00		237.8	72.4	930.3	1593.0	2.7	13
<i>Microcystis aeruginosa</i>	cyanobacterium	EC <sub>50</sub>	2460.00		178.9	54.5	699.6	1198.0	2.0	13
<i>Skeletonema pseudocostatum</i>	algal diatom growth inhibition	EC <sub>50</sub>	251.00		1753.0	533.9	6856.6	11741.0	19.9	14

<i>Chlorella vulgaris</i>	green microalgae growth inhibition	EC <sub>50</sub>	22400.00		19.6	6.0	76.8	131.6	0.2	15
<i>Chlorella vulgaris</i>	green microalgae growth inhibition 96h	EC <sub>50</sub>	6860.00		64.1	19.5	250.9	429.6	0.7	17
<i>Chlorella vulgaris</i>	green microalgae growth inhibition 96h	EC <sub>50</sub>	2980.00		147.7	45.0	577.5	988.9	1.7	18
<b>Fish</b>										
<i>Brachydanio rerio</i>	96h	LC <sub>50</sub>	14730.00		29.9	9.1	116.8	200.1	0.3	17
<i>Brachydanio rerio</i>	96h	LC <sub>50</sub>	3890.00		113.1	34.4	442.4	757.6	1.3	18

RED= Unacceptable Risk  $\geq 1$

Yellow= Potential of increased Risk  $\geq 0.5 < 1.0$

Green= Low Risk  $< 0.5$

White= not significant, below threshold for hazard quotient



## References

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